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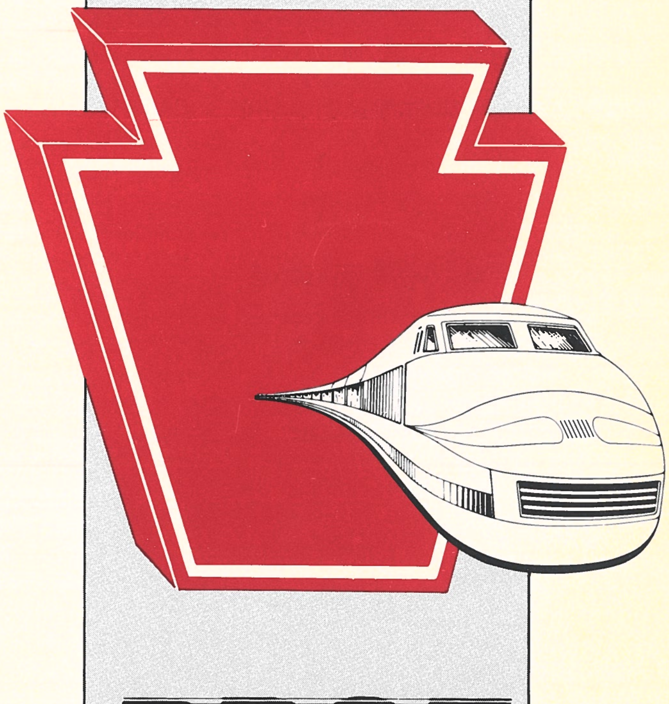
# PENNSYLVANIA HIGH SPEED RAIL FEASIBILITY STUDY

# EXECUTIVE SUMMARY

## PHASE 1

PREPARED FOR:

PENNSYLVANIA
HIGH SPEED
INTERCITY
RAIL PASSENGER
COMMISSION



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PARSONS BRINCKERHOFF/
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FEBRUARY 1985

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This executive summary is based on methodology, data, and assumptions contained in the study working papers and reports. Included in the assumptions are projections, made as of November 1984, concerning future events and economic conditions that cannot be assured. Therefore, actual results achieved may vary from the projections.

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## INTRODUCTION

A high-speed rail passenger system across Pennsylvania could not only offer rapid, all-weather travel between Philadelphia and Pittsburgh but also create tens of thousands of jobs, pump billions of dollars into the state economy, and spark countless opportunities for real estate development.

Such a super-railroad—able to move millions of riders a year from city center to city center in safety, style, and speed—also could boost state tax revenue by hundreds of millions of dollars and position Pennsylvania to export high-speed rail technology to other states.

In addition, such a network probably could generate enough revenue to pay its operating and maintenance costs, and perhaps make a contribution to the capital construction cost.

These are among the preliminary findings of a program begun in 1983 for the Pennsylvania High Speed Intercity Rail Passenger Commission by an engineering joint venture of Parsons Brinckerhoff Quade & Douglas, Inc., and Gannett Fleming Transportation Engineers, Inc.

Under most of the options studied, comfortable trains would zip along on approximately hourly schedules. The trains would ride new passenger-only trackage separate from existing freight tracks (but in many locations adjacent and parallel to them) and free from grade crossings.

By the year 2000, the study estimates, a high-speed rail system could carry 4 million to 12 million riders a year. The figure could run even higher if rail connections materialize at either end of the state—to Atlantic City, N.J., and to a proposed multistate Midwest high-speed network that has been envisioned to link Pittsburgh with Cleveland, Detroit, and Chicago.

Building the railroad, an 8- to 12-year program, could help stabilize the state's economy at a time when the national shift to a service society has forced many smokestack industries to close their plant gates.

Clearly, Pennsylvania stands at a crossroads of economic opportunity with high-speed rail.

For travelers, this service could slice the nearly 7-hour, 352-mile passenger-train run from Philadelphia to Pittsburgh to as little as:

- 2¼ hours (express service) for new magnetic levitation trains on special guideways, or
- 3¼ hours for advanced high-speed trains on steel wheels following a mostly new alignment, or
- 4 hours for a substantially improved steel-wheel system primarily following the existing right-of-way.

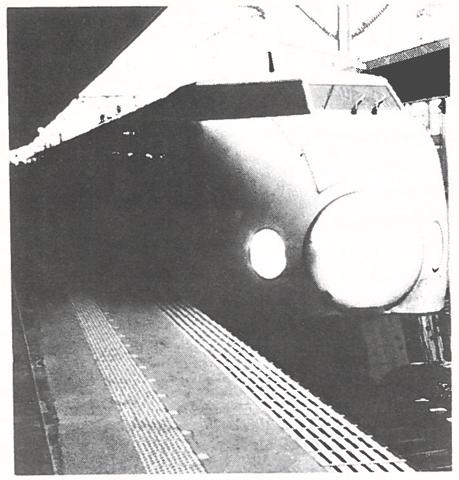
Such a system would give Pennsylvania a quality and frequency of service unknown in America but widely available in Japan and Europe, where clean trains safely and routinely whisk between major cities at speeds of between 125 mph and 168 mph. It also would help meet a growing demand for intercity transportation, which is expected to nearly double by the year 2000, according to a federal study.

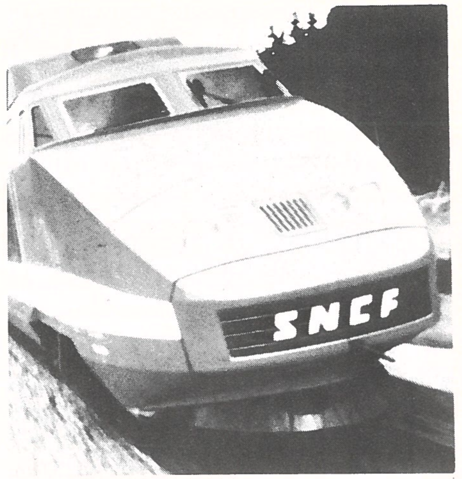
The main line envisioned by the Commission's study would connect with Amtrak's New York-Washington Northeast Corridor at 30th Street Station in Philadelphia. In Pittsburgh, the line could terminate either at Pennsylvania Station, as Amtrak trains now do, or at Station Square, the P&LE Terminal complex being redeveloped as a retail-hotel-restaurant center. Some of the route alignments studied closely follow the former Pennsylvania Railroad main line (today owned by Amtrak east of Harrisburg and by Conrail west of Harrisburg) for much of the distance, while others deviate widely from it. In all cases studied, however, trains would serve Paoli, Lancaster, Harrisburg, Altoona, Johnstown, and Greensburg. One route realignment proposal would add State College, home of Pennsylvania State University and a growing center for technology and research.

Highlights of other findings, which are covered elsewhere in this executive summary and in detail in the technical study itself, are listed below. Known as Phase 1, this part of the study laid a broad framework for more specific and intensive examination in Phase 2. Phase 2 will include a detailed market survey and a right-of-way inventory. Phase 3 will focus on economic development that high-speed rail (HSR) could stimulate and on a financing package.

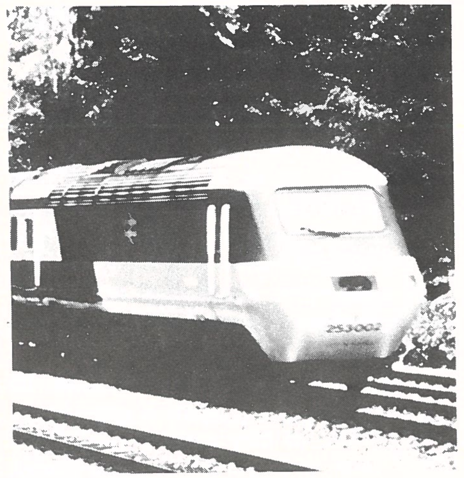
Among other findings, Phase 1 determined that:

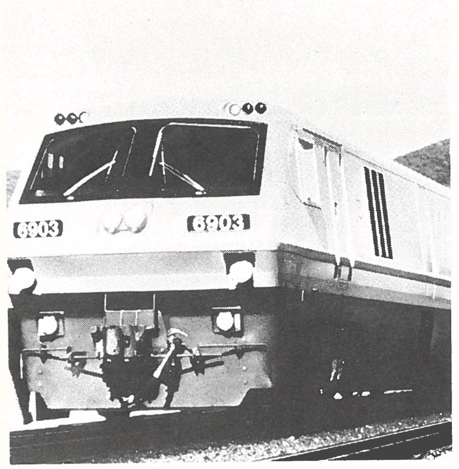
- Pennsylvania residents and firms can capture approximately 70 percent of the construction costs ($1.8 billion to build a 4-hour steel-rail system, up to $10 billion to build a 2½-hour [trains making all stops] magnetic levitation [maglev] system).
- Pennsylvania residents and firms can capture an even greater share—approximately 80 percent—of operating expenditures, year after year.
- A "multiplier effect" of successive rounds of spending might triple the impact of initial expenditures.
- The dollar value of time savings alone could exceed the capital costs of an HSR system.
- State tax revenues would increase.
- New jobs directly created in Pennsylvania by HSR can boost the Commonwealth's employment growth rate by 20 to 68 percent during the construction period and by 23 to 35 percent when service begins, depending on which of the high-speed rail systems is chosen.
- Existing commuter systems, such as the Southeastern Pennsylvania Transportation Authority (SEPTA) and Port Authority Transit of Allegheny County (PAT) might gain riders by serving as feeder service to HSR.
- Pennsylvania firms could leap to the forefront of a new HSR industry in the United States, benefiting from the development of a trained labor force, a strengthened base for an HSR supply industry, and investments in the new technology drawn to Pennsylvania by an HSR system.
- The competitive position of Pennsylvania industries relative to those of other states could be enhanced by the better transportation HSR will provide. This definite transportation advantage and its intangible effect on the state's image could attract new businesses.


*JNR Series 961 Bullet Train*

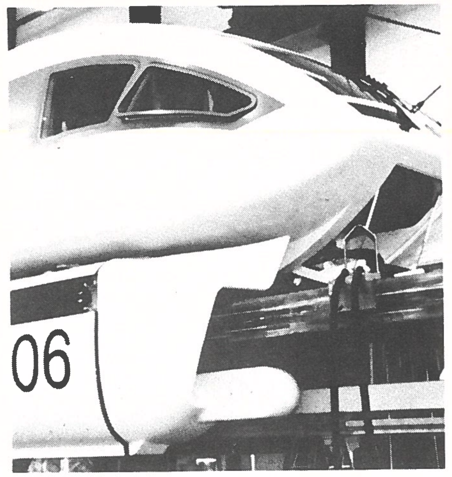


*SNCF TGV Train*

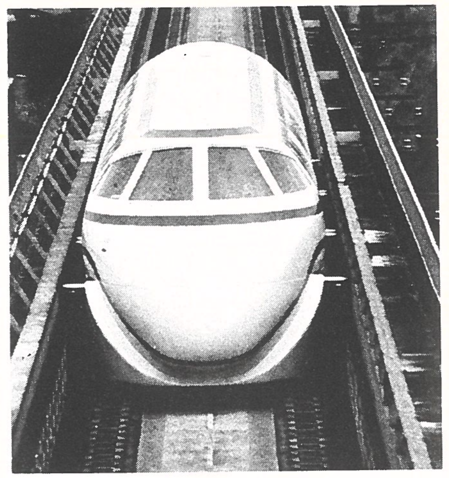

*British Rail HST Train*



*VIA Rail LRC Train*



*Transrapid 06 Maglev Test Train*


*JNR MLU-001 Maglev Test Car*

- Tourism could benefit. As tourists are drawn from farther afield by the improved accessibility, this market improvement might induce the creation of new tourist attractions and better amenities, drawing still more tourists in a synergistic effect. HSR service itself could be a tourist attraction, particularly in the more advanced forms.

## PENNSYLVANIA AND THE WORLD'S HIGH SPEED RAIL SYSTEMS

**State Perspective.** Pennsylvania has always been in the vanguard in the development of transportation, including canals, railroads, and the world's first limited-access superhighway, the Pennsylvania Turnpike, which is a financial success as well as an efficient transportation facility. Some of America's earlier fast trains were in Pennsylvania—in 1956 the Aerotrain's low center of gravity allowed it to traverse the largely twisting and mountainous Pennsylvania Railroad main line at speeds of well over 85 mph, reducing the travel time between Philadelphia and Pittsburgh to 6 hours—an hour less than the currently scheduled time. But in Pennsylvania as elsewhere in the country, the years from the 1950s on have brought comparative neglect of the rail system as national transportation policy—and heavy federal funding—gravitated toward an emphasis on highways and airports. To remedy the neglect of rail, boost the state's economy, and regain a leading role in transportation, the Pennsylvania General Assembly created the High Speed Intercity Rail Passenger Commission by Act 144 of 1981 "to investigate, study and make recommendations concerning the need for and establishment and operation of a high speed intercity rail passenger system in the Commonwealth."

**National Trends.** The need for HSR passenger service is dictated by transportation growth trends. The final report of the National Transportation Policy Study Commission (1979) estimated that, even if the population were to stay constant in the 25-year period from 1975 to 2000, the number of intercity person-trips could be expected to rise by some 88 percent, from more than 13.5 billion annually to nearly 25.5 billion. According to the study, this results from the following trends:

- Expansion of service industries and white-collar occupations will cause business travel to increase faster than general economic growth.
- Increased affluence and leisure time will stimulate pleasure travel.
- Changing age distributions mean that there will be more persons in high-travel-potential age groups.
- The trend toward fewer dependents will allow more time and disposable income for travel.
- The rising relative affluence of other countries will increase tourism to the United States.

The federal study took special note of the absence of an efficient travel mode for short-distance intercity markets—a niche HSR might fill:

> Present intercity service offers limited speed and cost options. In short-range markets, there are no substantial high-speed options—air being relatively slow due to excessive access times, and the auto and bus being fixed at a maximum upper speed limit of 55 miles per hour. This market is often indicated as having potential for high-speed rail service; however, substantial capital investment is required. Where auto, bus and air speeds are often impaired by road and airway congestion, rail services may gain market share when rail speeds and service levels begin to compare favorably with the other modes.

**The World View.** Two basic systems were selected from world technologies as possible models for Pennsylvania:

- Steel-wheel-on-steel-rail. These systems are currently running at speeds of 125 mph or more in France, Great Britain and Japan—hundreds of route-miles in each country. They are fast, comfortable, and—particularly those propelled by electric power—produce little wayside air pollution. For electric trains, combustion takes place in the power generating plant, where it can be controlled, and fuel at the plant can be coal or hydropower instead of scarce oil. The initial Japanese high-speed line, known as the Shinkansen, has been running "Bullet Trains" since 1964—at a profit year after year. Tested at a maximum speed of 198 mph and operating at about 130 mph, it has sped along for more than 20 years without a single fatality or serious injury to passengers, making it the safest transportation system in history. The new French TGV (très grande vitesse or "very high speed") trains run even faster—168 mph normal top speed; tested to as high as 236 mph—again, at a profit for the initial line. Since 1975, British Rail has operated "Inter-City 125" service with HST (High-Speed Train) diesel-powered equipment at 125 mph. In addition, British Rail is running an electric-powered train called APT (Advanced Passenger Train) with coaches that tilt, enabling them to round conventional curves faster than otherwise would be comfortable for passengers. Canada also has a tilt-body design, the LRC (Light, Rapid, Comfortable), in service and undergoing continuing development. Using AEM-7 electric locomotives with Swedish-licensed technology and Amfleet coaches, Amtrak's Northeast Corridor intercity service runs at a top speed of 120 mph on certain stretches.
- Maglev. In a magnetic levitation, or maglev, system, magnets on the train interact with conductors embedded in a special guideway, propelling the train forward and, as it gathers speed, lifting it up. The train floats from a fraction of an inch to a few inches above the guideway surface itself, avoiding contact noise, vibration, and friction. Experimental maglevs are now running in Japan and Germany at speeds as high as 250 mph, based on different approaches. They are termed "repulsion" and "attraction" maglevs respectively, after the differing ways in which each country uses magnets to provide levitation. An early Japanese maglev attained a world speed record of 321 mph. One maglev has entered low-speed regular service at the Birmingham Airport in England. For Pennsylvania, 250 mph seems a reasonable top practical speed—avoiding the worst aerodynamic drag and noise.

The Commission and eventually a broader group of Pennsylvania leaders will face one fundamental distinction between these two classes of HSR systems: maglev operates on a different principle from rail, requires its own guideways, and cannot be simply added on to an existing rail system. Steel-wheel-on-steel-rail technology, on the other hand, can be developed by stages, with advanced vehicles running at less than top speeds over ordinary tracks for a time, or a diesel system built first and electrified later.

## ALTERNATIVES FOR PENNSYLVANIA

**Achieving Higher Speeds.** Travel times can be cut by using combinations of engineering techniques. Several alternative systems are described here, each using an integrated combination of track, alignment, operations, and equipment improvements. Among track, alignment, and operations improvements considered in the study were:

- Upgrading track to higher Federal Railroad Administration (FRA) classification—may be a requirement for higher speed.
- Raising superelevation (banking curves more steeply)—an inexpensive way of obtaining higher speed curves if track can be "dedicated" to passenger service.
- "Designation" of track for passenger service—may avoid the expense of constructing additional trackage specifically designed and dedicated for passenger service.
- Curve straightening—may avoid the cost and impact of route realignment, with nearly the same improvement in speed capability.
- Route realignment—may be desirable in areas where existing route is circuitous or where sharp curves exist.
- New alignment—may be the only way to obtain desired shorter trip times.

Among equipment improvements considered in the study were various combinations of the following:

- Increased power density (horsepower per ton)—may provide improved performance at a reasonable cost.
- Running with increased cant deficiency (tilt-body vehicles)—may increase passenger comfort and raise speed on curves, thus significantly improving performance at a reasonable cost.
- Electrification—though costly be-

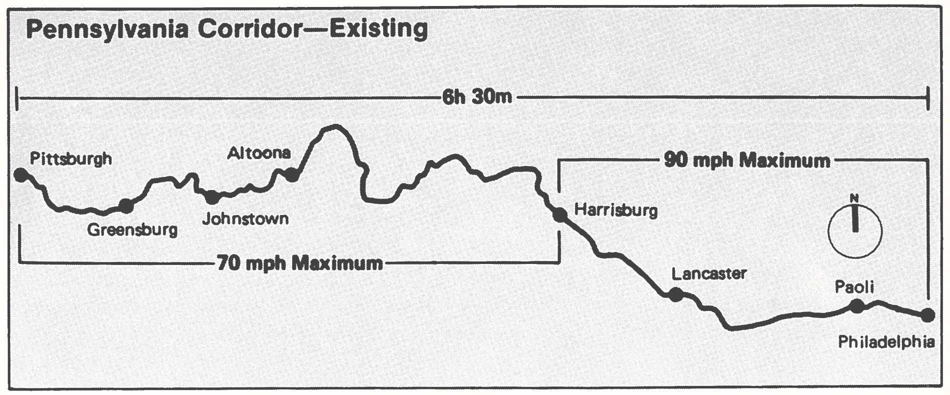
- cause of the need for an overhead catenary, saves train weight and may be the best way to provide the desired performance.
- Advanced technology (maglev)—though costly and not yet proven in commercial operations, it is the only way to provide ground transportation times as low as 2¼ hours (express) between Philadelphia and Pittsburgh.

**Existing Service.** Today, Amtrak cross-state passenger trains (the Broadway Limited and the Pennsylvanian) use Electro-Motive F40PH-type diesel locomotives to draw Amfleet and Heritage Fleet cars. The trip is slow, averaging 47 to 50 mph, mainly because of track and route bottlenecks and because of the mixture of freight and passenger trains on one of the highest tonnage railroads in the country. The 352-mile route has 40 grade crossings, 593 bridges, two tunnels, and 392 curves, or 1.1 per mile, a substantial proportion. With top speeds of 70 mph on the Conrail line west of Harrisburg and 90 mph on the Amtrak line east of Harrisburg, total trip time is a calculated 6½ hours, though currently scheduled with leeway at 6 hours 56 minutes. Amtrak service on the electrified Philadelphia-Harrisburg line is more frequent—nine trains a day each weekday—and runs at a slightly higher average speed—about 65 mph. These trains use Budd-built Metroliner coaches originally used in Northeast Corridor service.

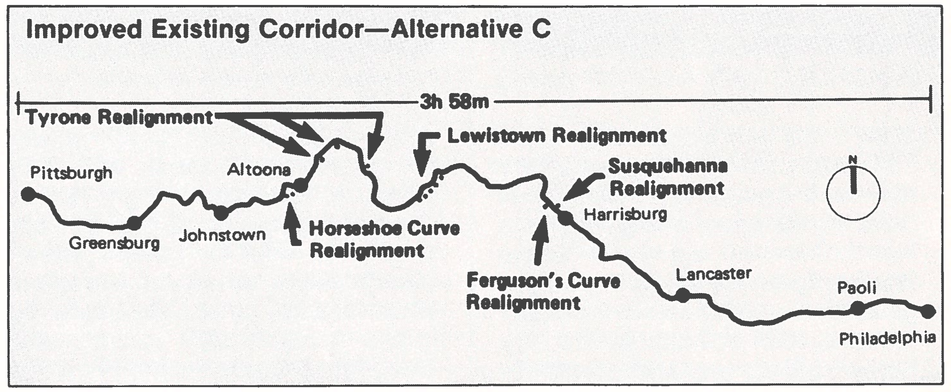
The study focuses on three progressively faster—and costlier—systems, each of which uses a specific vehicle type and route alignment. For purposes of the study, these are Alternatives "C," "D," and "E." (Alternative "A" was existing or "baseline" service, used as a point of comparison only; and Alternative "B" embraced only minor improvements to existing service—it was dropped from further consideration because it fell too far short of the Commission's stated performance goals.)

**Cities to be Served.** In all alternatives, seven population centers would be served, as required in the Commission's original Request for Proposal: Lancaster, Harrisburg, Altoona, Johnstown, and Greensburg, in addition to the terminal cities of Pittsburgh and Philadelphia. Service at Paoli was also examined to draw on the large suburban ridership base of the metropolitan Philadelphia area, including the new high-tech corridor that is developing along Route 202 near Paoli. Another growing high-tech area, Centre County, could be served by a routing through State College (studied under Alternative D, but also possible under C or E).

The details of providing commuter service and intermediate stops can be studied later, but it should be possible to operate these services in coordination with through trains.



**Pennsylvania Corridor—Existing**



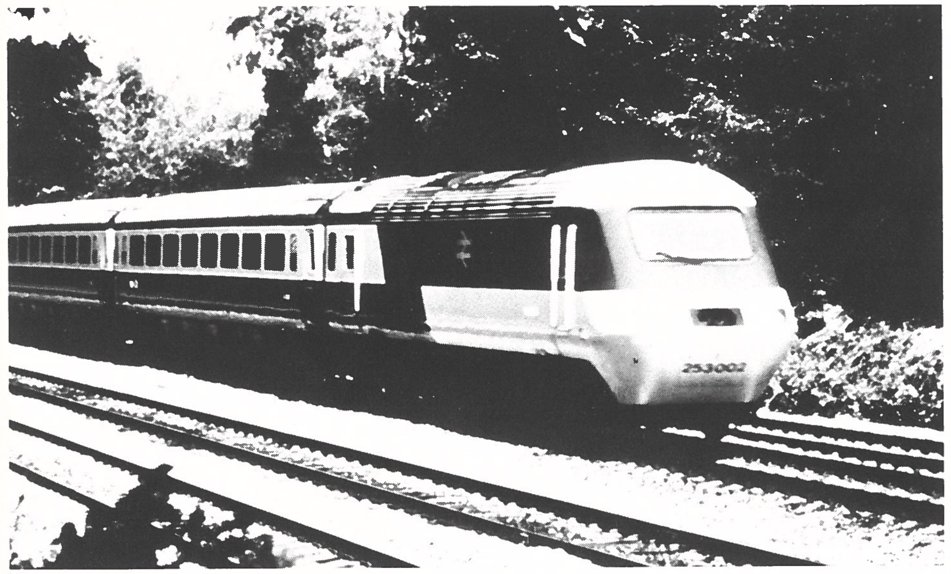
**Improved Existing Corridor—Alternative C**

**Alternative C—Improved Existing.** Alternative C is a big step up from the existing service, and could well serve as a transition to even higher-speed service later. It represents the best service that could be provided on essentially the existing right-of-way (or one parallel to it) with dedicated passenger tracks, limited curve improvements at many points, and route realignments at five current bottlenecks. Listed east to west, these realignments are:

- Susquehanna River reroute: runs north from Rockville, roughly following Conrail's Harrisburg-Buffalo main line and crossing river to Duncannon (saving 9.0 minutes).
- Ferguson's Curve east of Newport: straightens wide curve along the Juniata River (2.3 minutes).
- Lewistown to west of McVeytown: follows base of Blue Mountain on straight alignment (12.3 minutes).
- Tyrone: series of curve straightenings between Petersburg and Tyrone (15.3 minutes).
- Horseshoe Curve: bypasses the historic engineering landmark on a high viaduct (6.3 minutes).

High-speed locomotives and cars would be used, perhaps of tilt-body design; grade crossings and other obstacles eliminated where possible; and speed, comfort, and reliability much improved. Diesel or electric locomotives could be used (the electified option was termed Alternative C—Electric): diesel offers freedom from the capital expense of electrification, but electric trains operating from wayside power offer quicker acceleration or higher top speed. Diesels might be either the Canadian LRC (a tilt-body train built to North American standards and used in Canada since 1982, desirable if substantial route curvature is present) or the lightweight but nontilting British HST. Several electric trainsets are candidates in Alternative C—Electric: the American AEM-7 locomotive with Amfleet cars, as used in current Metroliner service on the Northeast Corridor; an electric version of Canada's LRC now under development; the West German ET 402, the Italian ETR 401 (tilt-body); or the British APT (tilt-body). Top speeds in this improved existing system would be 110 to 120 mph—nearly as high as true HSR service—and the trains could sustain high speeds throughout more of the trip than at present for substantially improved typical trip times (estimated at 3 hours 58 minutes; or 3 hours 50 minutes if electrified—both times assume trains stop at all stations considered in the study). Many of the improvements envisioned in Alternative C can be seen as steps toward even higher-speed service, allowing a smooth transition and the early inauguration of a service much superior to the present standard.

*VIA Rail LRC Train (Canada)*



*British Rail HST Train*

*Amtrak AEM-7/Amfleet Train (United States)*

**Alternative D—True High Speed Rail.** Alternative D represents the best service possible with advanced steel-wheel-on-steel-rail rolling stock and motive power, using essentially new right-of-way. It uses a new alignment and advanced HSR technology modeled after the French TGV or Japanese Bullet Train, but realistically adapted to Pennsylvania topography to avoid excessive construction through tunnels or on structures. Three trainsets are candidates:

- French TGV (currently operating to as high as 168 mph; the export version intended for the United States would use synchronous alternating-current traction motors in place of the direct-current motors used in France).
- Japanese Series 961 Bullet Train (currently operating at 130 mph and somewhat more powerful than others in the Bullet Train series).
- Proposed German Intercity Experimental (IC-E) train (expected to begin prototype testing in December 1985).

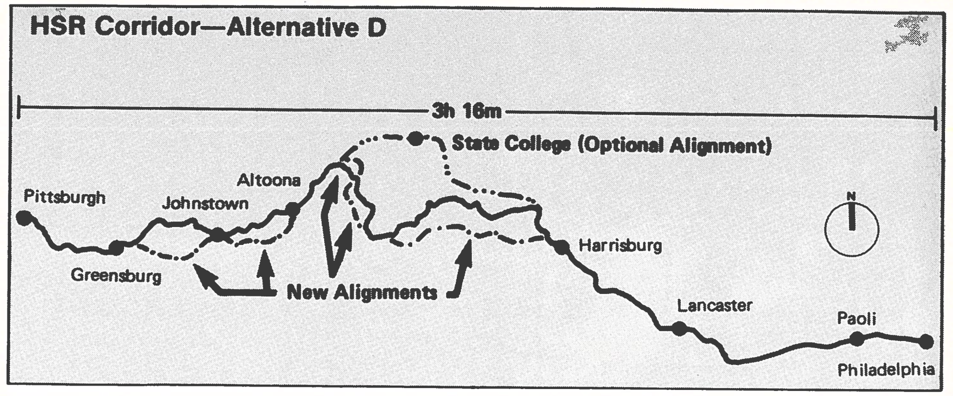
As originally conceived, **Alterna-**

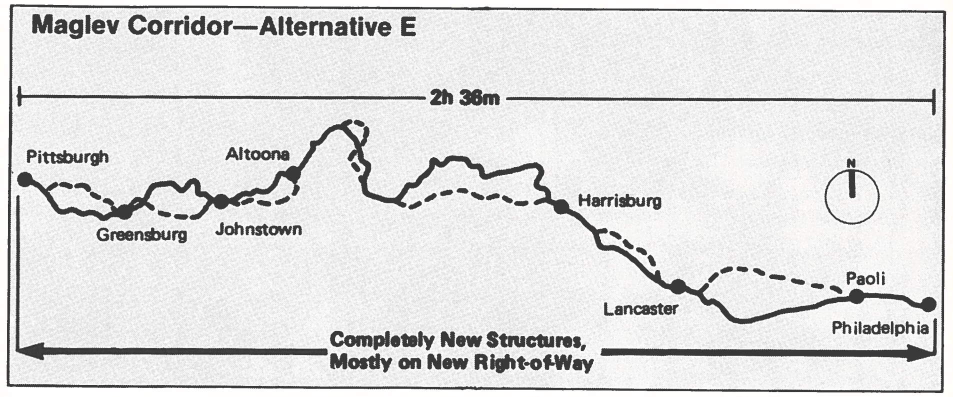
tive D would not have followed the existing Amtrak/Conrail route as much as it does; an analysis of the marginal trip time savings, the high cost, and the large environmental impact of new alignments in urban areas, however, persuaded the study team to propose using the existing right-of-way between Philadelphia and Harrisburg, between Greensburg and Pittsburgh, and in the vicinity of passenger stations; elsewhere it would be new. Electrically powered trains would operate on new, passenger-dedicated trackage at a top speed of 160 mph (180 mph was also analyzed, but grade and curvature severely limit the marginal trip time savings). With six intermediate stops, the 314-mile route would take an estimated 3 hours 16 minutes.

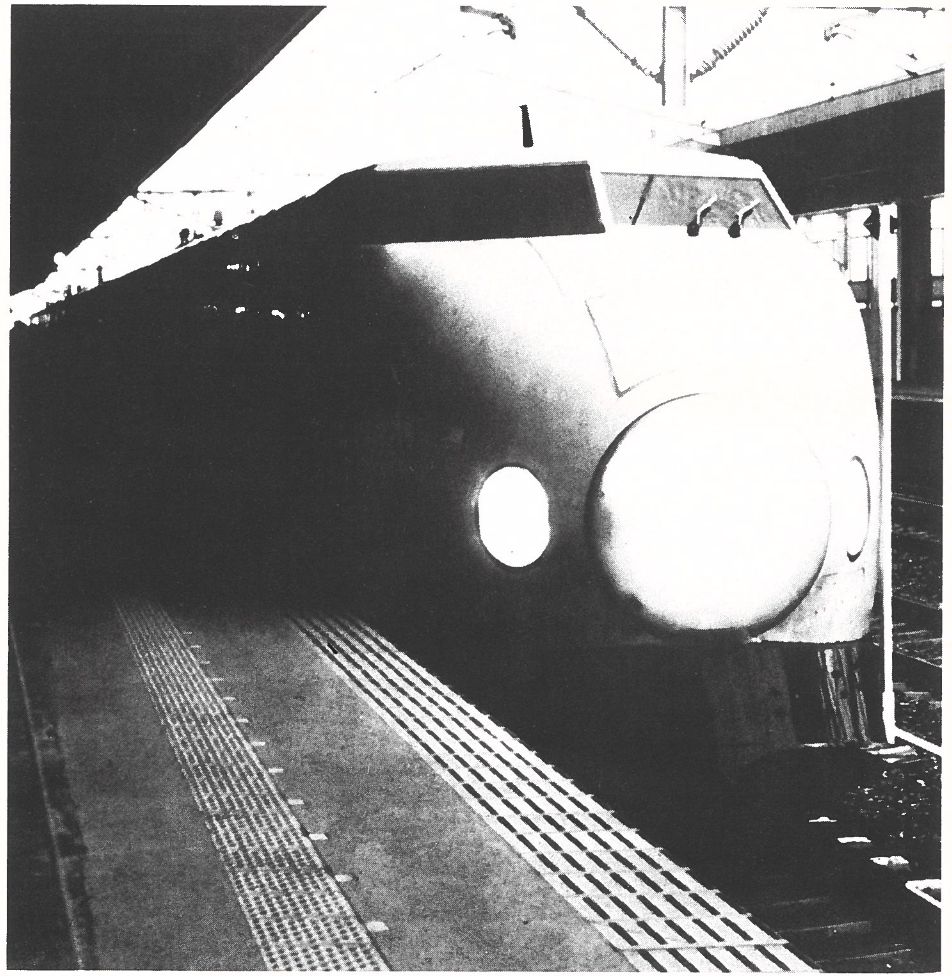
**Alternative D—State College.** An alternative routing via State College was examined, the only realignment studied for market reasons rather than for trip-time improvement. Although studied as a variant of Alternative D, placing State College on an HSR corridor also could be done with Alternative C or E.

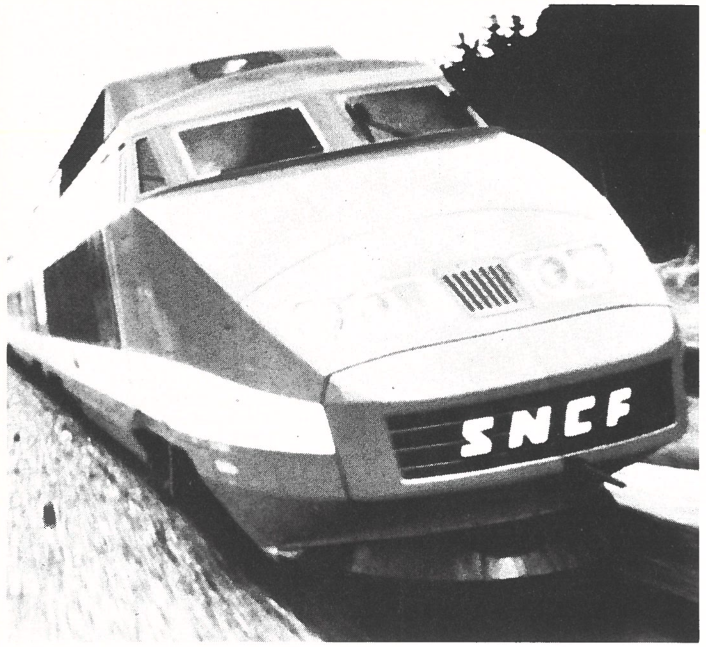
West of Harrisburg, the line would follow the Conrail main line as far as Millerstown, where it would diverge, tunneling through three mountains before emerging into the Nittany Valley. The route would pass south of State College and climb over Bald Eagle Mountain, joining the right-of-way of the former Conrail Bald Eagle Branch a few miles west of Port Matilda. From there, the alignment follows the branch until joining the main line at Tyrone.

This realignment would add about 5 miles and 10 to 12 minutes to the running time estimated for Alternative D. The cost of routing Alternative D through State College is estimated at $77 million above the base cost for Alternative D. If built as part of Alternative C, it would save about 7 minutes of running time. The cost of routing Alternative C through State College, while not estimated in Phase 1, would be substantial. For Alternative D, the additional market could boost ridership by as much as 650 to 1,690 passengers a day, or 237,250 to 616,850 riders annually.

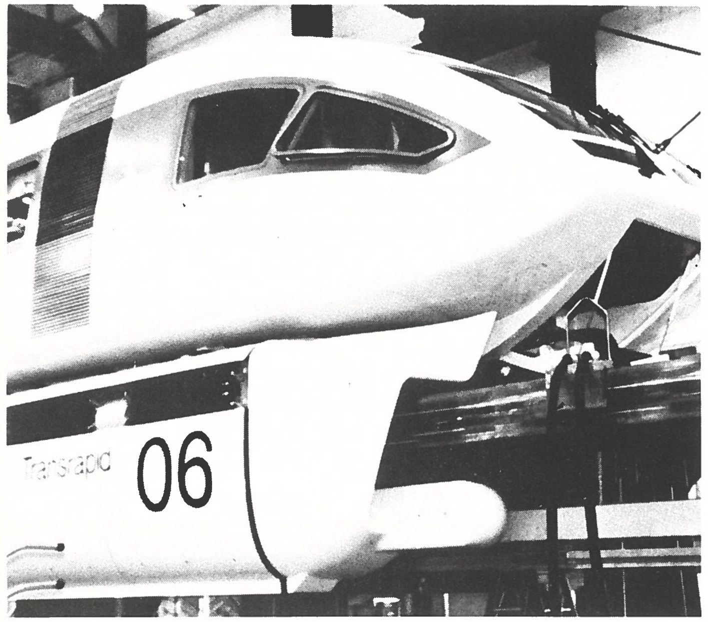

HSR Corridor—Alternative D


Maglev Corridor—Alternative E

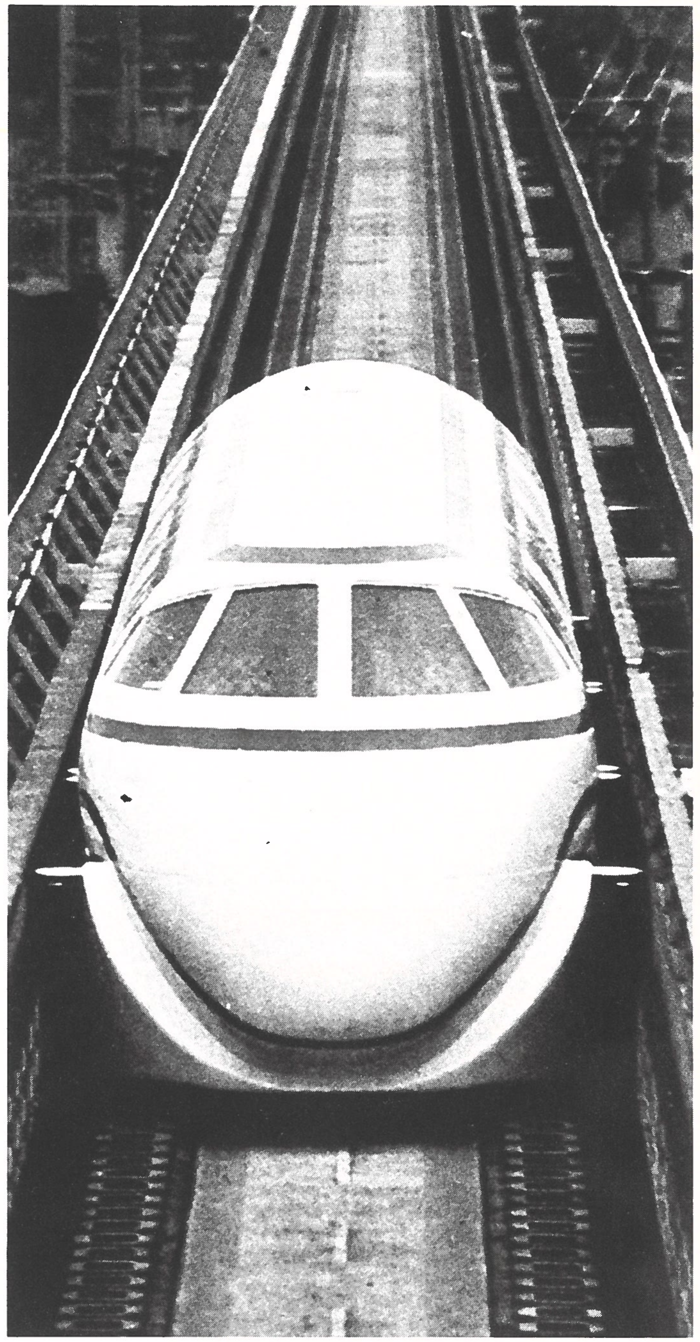

*JNR Series 961 Bullet Train (Japan)*



*SNCF TGV Train (France)*



*Transrapid 06 Maglev Test Train (Germany)*


*JNR MLU-001 Maglev Test Car (Japan)*

**Alternative E—Magnetic Levitation.** Alternative E represents the best service possible with magnetic levitation, using a totally new right-of-way. This new very-high-speed system could be modeled after either of two experimental vehicles:

- German attraction maglev, using a T-shaped guideway
- Japanese repulsion maglev, using superconducting coils and a U-shaped guideway.

A new system of guideway would be built within a portion of the existing right-of-way between Philadelphia and Malvern, and on a new right-of-way from there west to Pittsburgh. The guideway would principally be double, but near stations it would return to the existing right-of-way and become single. A full double guideway would be impractical in narrow rights-of-way through cities. Elevating the guideway when crossing sensitive areas such as farmland would permit continued use of the surrounding land. Tunneling and earthwork can be minimized because maglev can negotiate steeper grades than steel-wheel HSR systems (the study assumed use of 6 percent grades, though steeper grades are possible). Maglev acceleration and maximum speed are high enough that route length (313 miles) becomes a secondary issue, and straightness of primary concern. Speeds as high as 250 mph would be practical, providing an estimated trip time of 2 hours 36 minutes if all station stops are made.

### Infrastructure Component Summary

| Item | Alternative C | C-Electric | D | E |
|---|---|---|---|---|
| **Track** | Upgraded existing 2 tracks (Philadelphia-Harrisburg)<br>1.5 new tracks (Harrisburg-Pittsburgh)<br>(wood ties) | | Entirely new double (concrete tie) track | New guideway |
| Maximum Track Super-elevation/Guideway Bank Angle | 6" | | 6" | 12° |
| Maximum Grade | 3 percent | | 3.5 percent | 6 percent |
| Maximum Speed (mph) | 110-120 | | 160-180 | 250 |
| **Grade Crossings** | Eliminated where feasible | | 100% eliminated | 100% eliminated |
| **Fencing** | 10% of ROW | 10% of ROW & OH Bridge | 100% at-grade ROW & OH Bridge | 100% at-grade ROW & OH Bridge |
| **Electrification** | Not used | Upgraded: Philadelphia-Harrisburg<br>New: Harrisburg-Pittsburgh | Upgraded: Philadelphia-Harrisburg<br>New: Harrisburg-Pittsburgh | All new |
| **Communications & Signals** | Upgraded existing | Upgraded: Philadelphia-Harrisburg<br>New: Harrisburg Pittsburgh | All new | All new |
| **Stations** | Rehabilitated existing and new (high-level platforms) | | Rehabilitated existing and new (high-level platforms) | All new |
| **Maintenance Facilities** | All new | | All new | All new |

## COST ESTIMATES

Cost estimates are shown in the table. For a system that would handle a base ridership demand (more conservative estimate), the target estimates range from $1.8 billion for Alternative C to $7.2 billion for D and $10.0 billion for E.

### Capital Cost Estimate Summary
Base Demand, 1983 Dollars in Millions

| Element | Alternative C | C-Electric | D | D-State College | E |
|---|---|---|---|---|---|
| Track/Guideway & Structures | $ 997.7 | $ 1,051.1 | $ 4,646.4 | $ 4,671.1 | $ 4,304.2 |
| Stations | 31.7 | 31.7 | 40.8 | 45.1 | 48.6 |
| Electrification, Communications & Signaling | 128.6 | 325.9 | 384.1 | 412.3 | 2,678.2 |
| Maintenance Facilities | 50.2 | 55.5 | 61.8 | 61.8 | 105.5 |
| Subtotal 1 | $ 1,208.3 | $ 1,464.2 | $ 5,133.1 | $ 5,190.3 | $ 7,136.5 |
| Engineering & Construction Management @ 18% | 217.5 | 263.6 | 924.0 | 934.3 | 1,284.6 |
| Subtotal 2 | $ 1,425.8 | $ 1,727.8 | $ 6,057.1 | $ 6,124.6 | $ 8,421.1 |
| Contingency @ 15% | 213.9 | 259.2 | 908.6 | 918.7 | 1,263.2 |
| Subtotal 3 | $ 1,639.7 | $ 1,987.0 | $ 6,965.7 | $ 7,043.3 | $ 9,684.3 |
| Vehicles (Including Test @ 10% & Contingency) | 205.2 | 216.8 | 203.3 | 203.3 | 339.8 |
| Target Cost Estimate | $ 1,844.9 | $ 2,203.8 | $ 7,169.0 | $ 7,246.6 | $ 10,024.1 |
| Additional Contingency @ 25% of Subtotal 2 | 356.4 | 432.0 | 1,514.3 | 1,531.2 | 2,105.3 |
| Maximum Cost Estimate | $ 2,201.3 | $ 2,635.8 | $ 8,683.3 | $ 8,777.8 | $ 12,129.4 |

## BENEFITS

**Transportation Benefits.** HSR brings shorter trip times—as low as 2½ hours end-to-end for Alternative E (maglev). Riders also benefit from the greater choice of arrival and departure times and the generally better service than that available today. The better the service and the more advanced the HSR system, the more riders attracted: Alternative C is estimated to draw an annual base demand of 4 million passengers, Alternative E nearly 6 million.

Time savings are fundamental. Over the years, the dollar value of these time savings could equal the system's capital costs—in as little as 4.8 years for the lowest-cost Alternative C or 12.4 years for Alternative D and maglev (Alternative E), which save more time for more people, but also cost more.

Less favorable assumptions for ridership demand and for the value of time require longer payback periods, from 36.4 years (C) to 85.7 years (E), but in all cases, the value of time savings is a benefit to riders that could compensate public support.

**Economic Benefits.** Beyond these transportation benefits, HSR would boost employment, personal income, the gross state product, and state tax revenue.

Unemployment is a key issue for Pennsylvania, as noted in the State Planning Board's 1980 *Choices for Pennsylvanians*:

> In Pennsylvania, the lack of sufficient jobs is one of the most severe problems facing us today. During the last 10 years, the Commonwealth has lost 190,300 manufacturing jobs. . . . Hardest hit have been the cities and towns that once relied on factory and service workers for support of their economic base. Fewer people with fewer dollars has meant less business for the retail establishments and less municipal revenue for the communities of Pennsylvania.

These negative trends have continued since the 1980 report. HSR could provide:

- From 58,000 to 292,000 person-years of employment (for Alternatives C and E, respectively), or 7,000 to 24,000 jobs on average for each year of the construction period.
- New permanent employment once operation begins—8,300 jobs under Alternative C by the year 2000; 12,500 jobs under Alternative E.
- Increases in the employment growth rate of from 20 to 68 percent during construction years and from 23 to 35 percent when service begins.

Naturally, the more money spent on the system, the greater the returns, particularly during the construction period (8, 10, or 12 years for Alternatives C, D, and E, respec-

### Operating and Maintenance Costs
Base Demand, 1983 Dollars in Millions

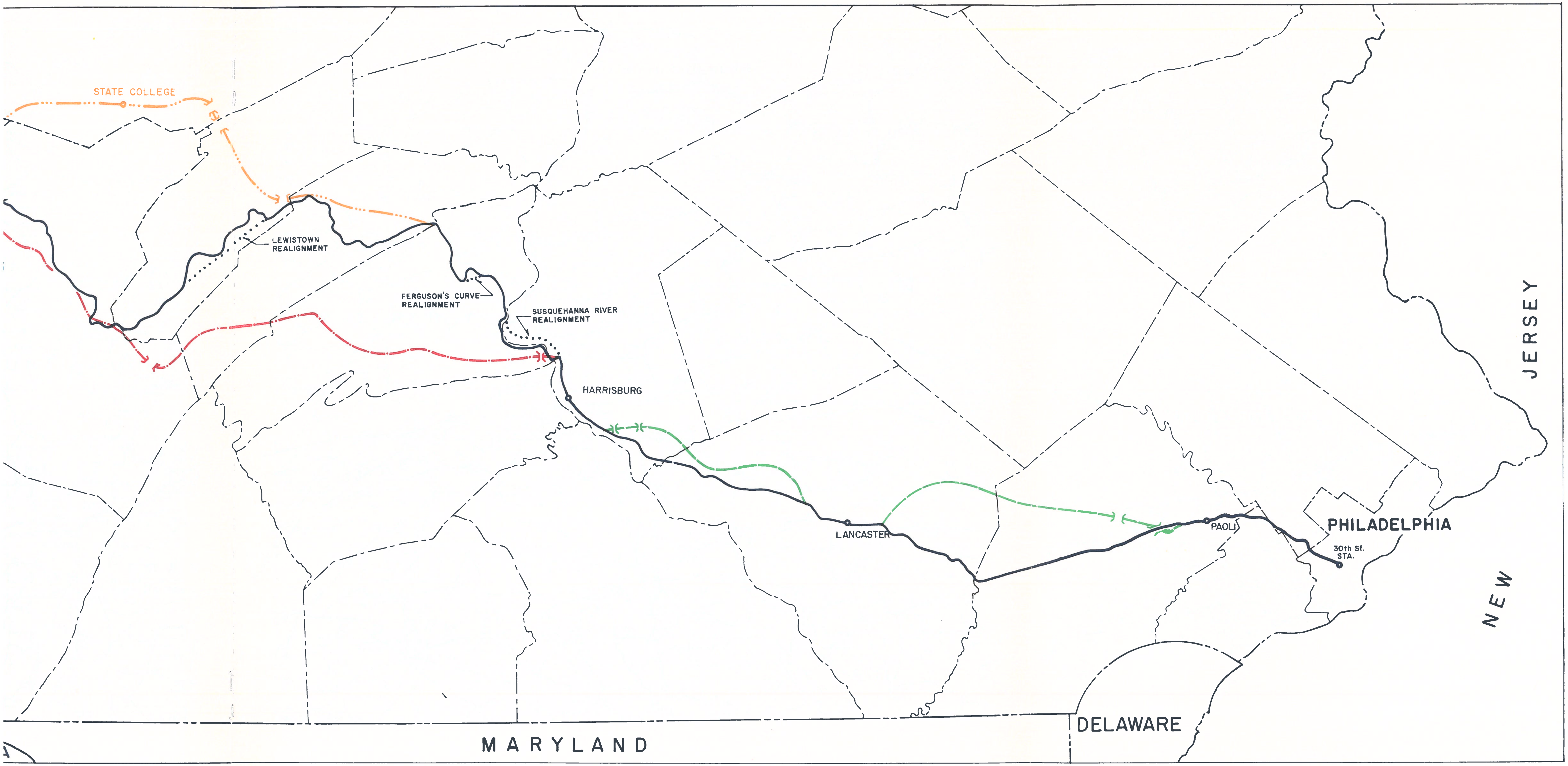
| Item | Alternative C | C-Electric | D | E |
|---|---|---|---|---|
| Track/Structures | | | | |
| Labor | $ 15.64 | $ 15.64 | $ 19.78 | $ 21.07 |
| Material | 15.24 | 15.24 | 15.40 | 12.89 |
| Electrical Maintenance | | | | |
| Labor | -- | 5.86 | 6.60 | 32.77 |
| Material | -- | 2.77 | 3.08 | 21.49 |
| Vehicle Maintenance | | | | |
| Labor | 17.73 | 9.57 | 15.84 | 11.64 |
| Material | 8.82 | 4.68 | 8.77 | 8.61 |
| Station Operation & Maintenance | | | | |
| Labor | 5.92 | 5.92 | 6.95 | 9.91 |
| Material | 1.00 | 1.00 | 1.20 | 1.50 |
| Signals & Communications Maintenance | | | | |
| Labor | 7.84 | 7.84 | 6.60 | (Incl. in Elect.) |
| Material | 2.77 | 2.77 | 3.70 | |
| Train Operations | | | | |
| Vehicle Crew | 9.81 | 8.19 | 9.55 | 8.69 |
| Power | 8.17 | 10.98 | 11.41 | 18.74 |
| Central Operations & Administration | | | | |
| Operations Schedule | 1.55 | 1.55 | 1.55 | 1.55 |
| Administration | 3.89 | 3.68 | 4.44 | 5.44 |
| Material & Services | 6.09 | 5.93 | 5.91 | 7.91 |
| Insurance | 1.71 | 1.71 | 1.97 | 2.43 |
| Security | 1.44 | 1.44 | 1.44 | 1.44 |
| TOTAL | $107.62 | $104.77 | $124.19 | $166.19 |

### Selected Train Parameters

| Parameter | Alternative C | | C-Electric | | D | | E |
|---|---|---|---|---|---|---|---|
| Equipment Type | HST | Lightweight LRC | AEM7/ Amfleet | Electric LRC | TGV | 961 | TR-06 |
| Proposed Base Case Train Consist | 1-8-1 | 1-6-1 | 1-6 | 1-6-1 | 1-11-1 | 8 | 6 |
| Train Weight (Tons) Fully Loaded * | 395 | 560 | 430 | 500 | 640 | 605 | 375 |
| Horsepower | 4,500 | 7,000 | 7,000 | 12,000 | 8,650 | 11,800 | 13,200 |
| Hp/Ton | 11.4 | 12.5 | 16.3 | 24.0 | 13.5 | 19.5 | 35.2 |
| Seating Capacity + | 396 | 480 | 480 | 480 | 524 | 520 | 600 |
| Assumes Maximum $E_u$ (in) | 4.5 | 9 | 4.5 | 9 | 4.5 | 4.5 | 3 |

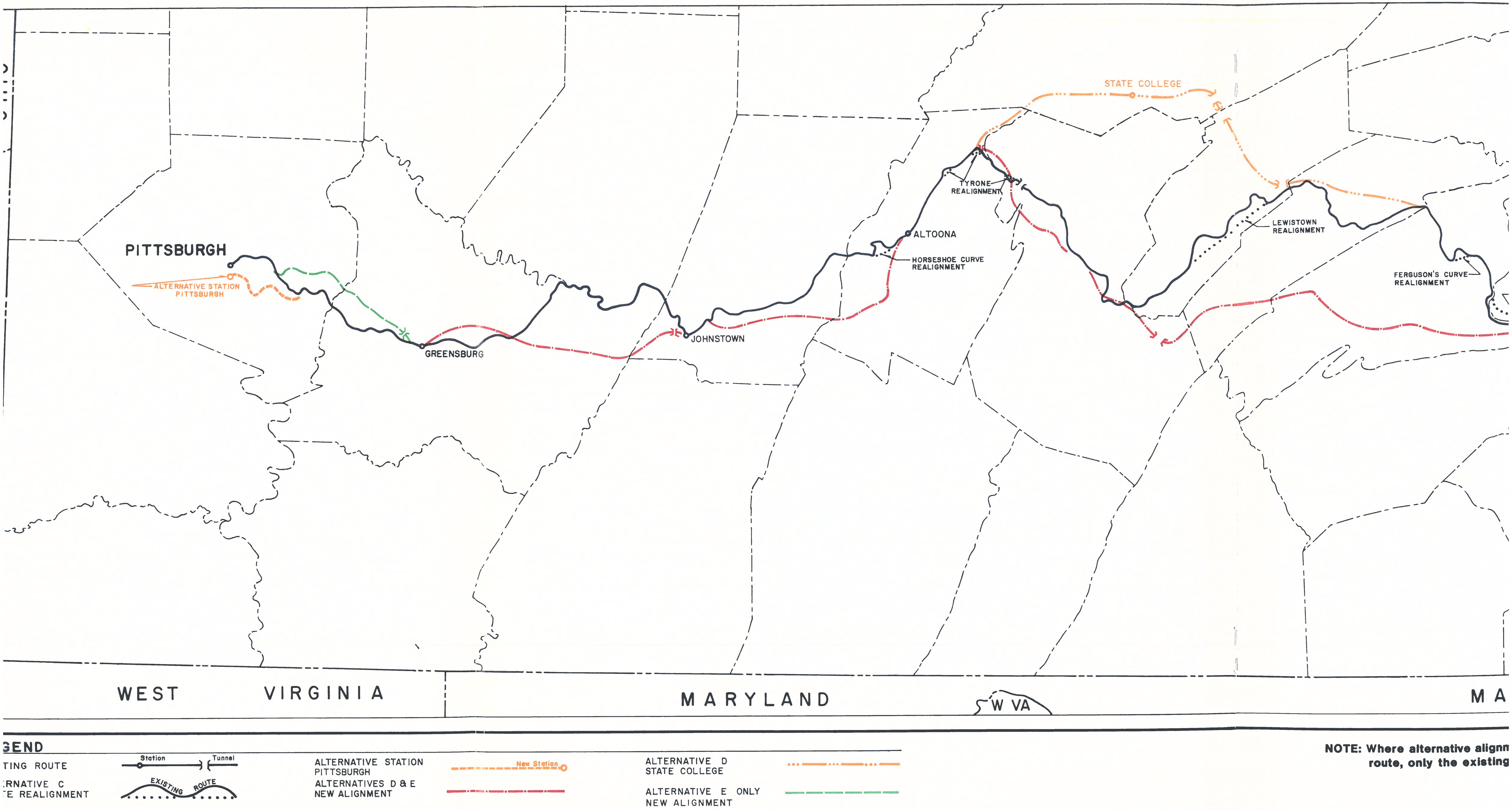
* Weights of all foreign equipment include structural modifications thought to be required to meet U.S. requirements (Based on IPEEP).

+ Seating capacity based on Amfleet seating density for all but the TR-06 (Maglev) vehicle.



**NOTE: Where alternative alignments coincide with the existing route, only the existing route is indicated graphically.**

**Pennsylvania Corridor Route Map**


PITTSBURGH
ALTERNATIVE STATION PITTSBURGH
GREENSBURG
JOHNSTOWN
ALTOONA
TYRONE REALIGNMENT
HORSESHOE CURVE REALIGNMENT
STATE COLLEGE
LEWISTOWN REALIGNMENT
FERGUSON'S CURVE REALIGNMENT
WEST VIRGINIA
MARYLAND
W VA
M A
GEND
TING ROUTE
Station
Tunnel
:RNATIVE C
'E REALIGNMENT
EXISTING ROUTE
ALTERNATIVE STATION PITTSBURGH
New Station
ALTERNATIVES D & E NEW ALIGNMENT
ALTERNATIVE D STATE COLLEGE
ALTERNATIVE E ONLY NEW ALIGNMENT

**NOTE: Where alternative alignn
route, only the existing**

## System Features

| Item | Alternative C<br>Improved Existing | C-Electric<br>Improved Existing (Electrified) | D<br>HSR | E<br>Maglev |
|---|---|---|---|---|
| **Alignment** | Base case: Existing route with 5 route realignments & 44 curve realignments | | Existing Route: Philadelphia-Harrisburg and Greensburg-Pittsburgh<br>New Route: Harrisburg-Greensburg | Existing Route: Philadelphia-Malvern<br>New Route: Malvern-Pittsburgh |
| **Track** | Upgraded existing 2 tracks: Philadelphia-Harrisburg; 1.5 new tracks: Harrisburg-Pittsburgh (wood ties) | | Entirely new double track (concrete tie) | New Guideway |
| Traffic Separation | Designated passenger tracks | | Dedicated HSR | Dedicated |
| Maximum Effective Curve Elevation* | Up to 15" (6" $E_a$ + 9" $E_u$) | | Up to 10.5" (6" $E_a$ + 4.5" $E_u$) | Up to 14.5" (12° bank angle + 3" $E_u$) |
| Maximum Grade | 3 percent | | 3.5 percent | 6 percent |
| Maximum Speed, mph | 110 to 120 | | 160 to 180 | 250 |
| **Grade Crossings** | Eliminated where feasible | | 100% eliminated | 100% eliminated |
| **Fencing** | 10% of ROW | 10% of ROW & overhead bridges | 100% At-grade ROW & overhead bridges | 100% At-grade ROW & overhead bridges |
| **Electrification** | Not used | Upgraded: Philadelphia-Harrisburg; New: Harrisburg-Pittsburgh | Upgraded: Philadelphia-Harrisburg; New:Harrisburg-Pittsburgh | All new |
| **Signals & Communications** | Upgraded existing | Upgraded: Philadelphia-Harrisburg; New: Harrisburg-Pittsburgh | All new | All new |
| **Stations** | Rehabilitated existing and new (high-level platforms) | | Rehabilitated existing and new (high-level platforms) | All new |
| **Maintenance Facilities** | All new | All new | All new | All new |
| **Equipment Type** | Diesel trainset (tilt-body or conventional) | Electric trainset (tilt-body or conventional) | High-speed electric train | TR-06 or MLU-001 type train |

* Maximum Effective Curve Elevation is defined as the sum of track superelevation (actual elevation, $E_a$) and unbalanced elevation ($E_u$).

## Potential Payback from Time Savings

| ALTERNATIVE | Demand | PAYBACK PERIOD, YEARS<br>Case A | Case B |
|---|---|---|---|
| C | Base | 11.6 | 36.4 |
| D | Base | 27.3 | 85.7 |
| E | Base | 25.6 | 80.5 |
| C | High | 4.8 | 15.1 |
| D | High | 12.4 | 39.0 |
| E | High | 12.4 | 38.9 |

## Typical Trip Times

| | ALTERNATIVE<br>Existing<br>TIME (MIN) | C<br>TIME (MIN) | C-Electric<br>TIME (MIN) | D<br>TIME (MIN) | E<br>TIME (MIN) |
|---|---|---|---|---|---|
| Philadelphia | | | | | |
| | 23 | 19 | 18 | 19 | 16 |
| Paoli | | | | | |
| | 40 | 31 | 30 | 30 | 19 |
| Lancaster | | | | | |
| | 32 | 23 | 23 | 24 | 16 |
| Harrisburg | | | | | |
| | 145 | 79 | 76 | 55 | 53 |
| Altoona | | | | | |
| | 58 | 29 | 27 | 21 | 17 |
| Johnstown | | | | | |
| | 52 | 32 | 31 | 21 | 16 |
| Greensburg | | | | | |
| | 40 | 25 | 25 | 26 | 19 |
| Pittsburgh | | | | | |
| Time, Total Route (hr:min) | 390 (6:30) | 238 (3:58) | 230 (3:50) | 196 (3:16) | 156 (2:36) |
| Route Length, miles | 352.0 | 340.1 | 340.1 | 314.3 | 312.9 |
| Average Speed, mph | 54 | 86 | 89 | 95 | 120 |

NOTE: Times include 90 sec dwell at all intermediate station stops.

tively). Most of the money spent would stay in Pennsylvania—70 percent during construction and a continuing 80 percent after operation begins.

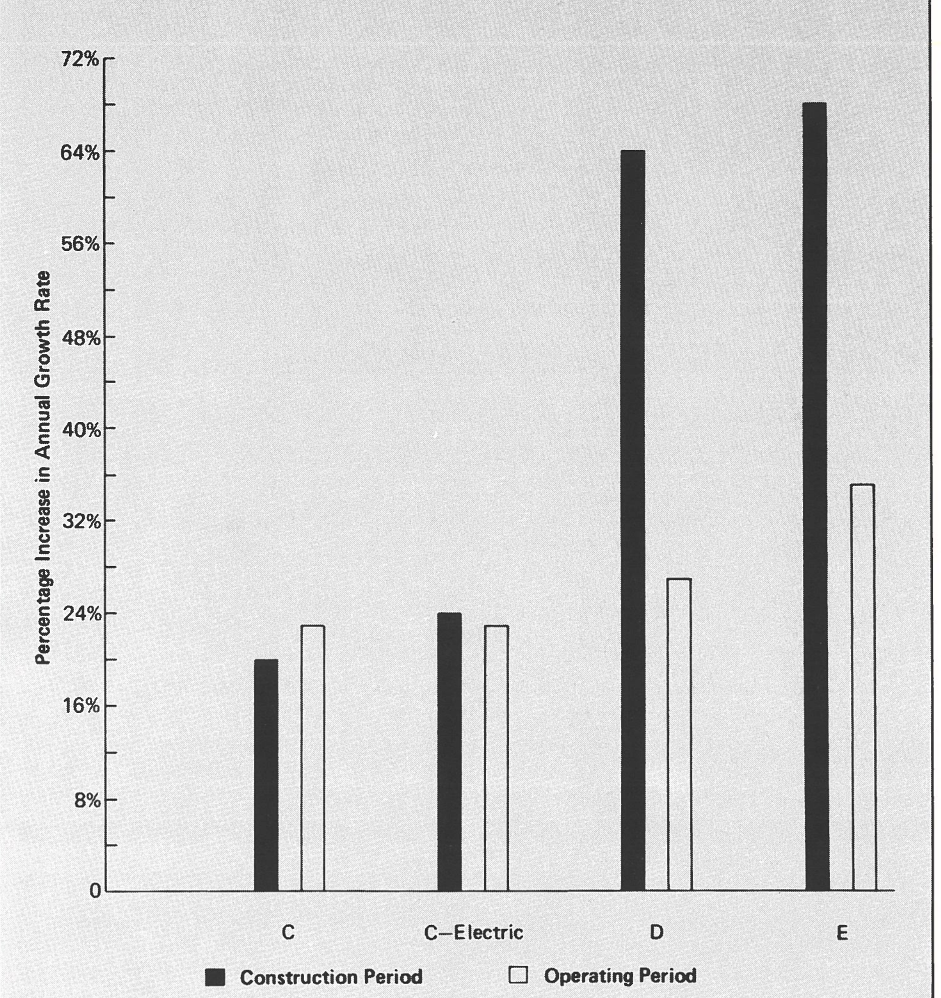
All alternatives provide the state government with additional financial resources that could assist in financing HSR, stemming solely from the existing tax structure:

- $12 million to $41 million per year during construction
- $13 million to $19 million per year during service, base ridership demand—or $18 million to $26 million, high ridership demand.

These additional tax revenues represent 1 percent or less of total current state government revenues, but boost the projected annual growth rate by as much as 31 percent. The additions could finance part of the HSR system's construction or operation, should the Commonwealth decide to make a financial commitment to the system. Costs to state government may decline modestly by the reduction in expenditures for new construction and for maintenance in other modes of transportation, and by the reduction in unemployment and associated public costs.

Urban economic development could be enhanced and downtown areas revitalized. New employment and greater personal income could be felt all along the route. How each city handles the fostering of development can make for differences among the cities. So can sheer size. The large urban areas have more heavy construction and railroad supply industries than the smaller ones and can capture larger percentages of Pennsylvania's share of construction costs: the Philadelphia Standard Metropolitan Statistical Area can capture 22 percent, Pittsburgh (including Greensburg) 28 percent. During both construction and operation, the larger general economies can also absorb more of the multiplier effect as new income is spent in the community. Proportionally, however, the smaller urban areas—Altoona, Harrisburg, Johnstown, and Lancaster—can look for equal or greater benefits relative to their smaller overall economies. Each city's success will depend on its own development policies and basic

## Impact of HSR on Employment Growth Rate
Base Demand



## Annual Ridership Summary
Year 2000 (thousands)

| | Base Demand | High Demand |
|---|---|---|
| **Alternative C** | | |
| Estimated Riders | 4,183 | 10,256 |
| Additional (Atlantic City) | 32 | 77 |
| Additional (Mid-State Resort) | 110 | 430 |
| Total | 4,325 | 10,763 |
| **Alternative D** | | |
| Estimated Riders | 5,146 | 11,676 |
| Additional (Atlantic City) | 43 | 74 |
| Additional (Mid-State Resort) | 110 | 430 |
| Total | 5,299 | 12,180 |
| **Alternative E** | | |
| Estimated Riders | 5,866 | 12,658 |
| Additional (Atlantic City) | 51 | 87 |
| Additional (Mid-State Resort) | 130 | 500 |
| Total | 6,047 | 13,245 |

economic vitality, but HSR can become a strategic spur to growth.

Summing up, economic impacts to Pennsylvania of an HSR corridor could include:

- $145 million to $415 million of new, direct expenditures annually during construction
- $115 million to $175 million annually during operation
- Total economic impacts over the 8- to 12-year construction period, including the multiplier effects of successive rounds of spending (approximately three times the size of the direct effects):
  - Between $3.9 billion and $22.7 billion in total expenditures for goods and services
  - Between $1.2 billion and $6.1 billion in gross state product
  - Between $1.0 billion and $5.2 billion in total personal income
  - Between 58,000 and 292,000 person-years of employment.

**Relative Benefits of Alternatives.** All the alternatives offer benefits, and in general, the greater the costs, the greater the benefits. Economic benefits correspond closely to costs, but transportation benefits begin to give less return per dollar at the highest costs. This behavior is typical of transportation projects: each additional minute of time savings costs more to achieve than the previous minute.

For producing transportation benefits, Alternatives D and E generate more total benefits than Alternative C, but at more than proportionately greater cost. For economic benefits, however, all are approximately equally efficient in generating benefits from costs.

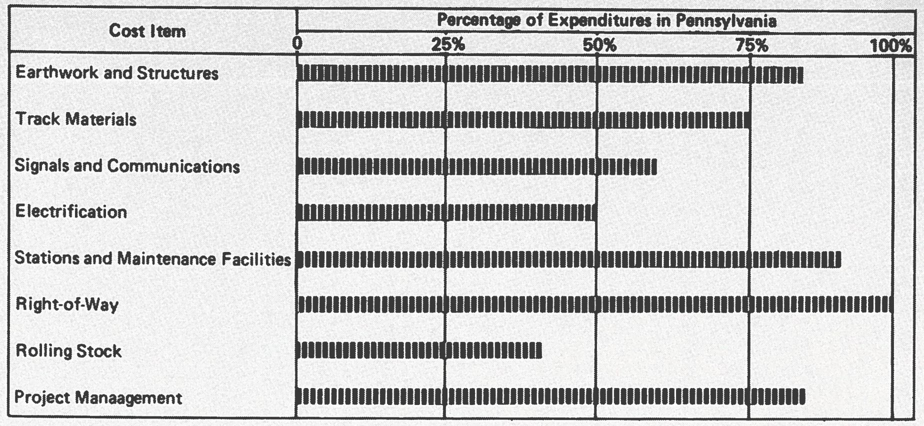
**Return on Investment.** HSR could pay for its own operation. Sources of revenue include both fares and "other revenues"—associated business enterprises such as package service; baggage and mail fees; charter services to special events; auxiliary revenue from station concessions and advertising; and the rental of space in stations. From these are subtracted the costs of travel agent commissions, food-service losses on the trains, and advertising. Calculated this way, revenues for the first year of operation are expected to fall within the following ranges:

- Alternative C—$113.92 million to $289.73 million
- Alternative D—$141.77 million to $322.16 million (or from $153.68 million to $347.18 million if State College is added)
- Alternative E—$181.92 million to $389.39 million

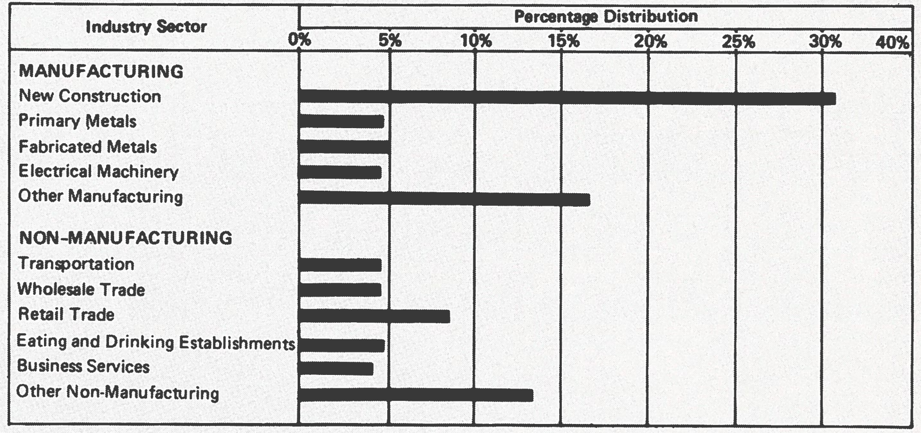
A creative and flexible combination of public and private support may be workable for HSR. Each stage in the project has peculiar features affecting financing and taxes: the project might evolve in stages from public to public-private ownership and control, drawing on the special tax and financing advantages of each. Private investors will require a direct return on investment commensurate with the perceived risk in developing the system. At this stage in the study it appears that all the alternatives would return enough revenue to cover operating costs, with Alternative C providing the highest internal rate of return on investment. If capital costs must also be covered from revenues alone, private investors might need added incentives, particularly for the more expensive and higher-risk alternatives. Such alternatives, with their greater total public benefits but only somewhat greater cash revenues, are more suitable to a public financing viewpoint. When such benefits as employment and supplementary economic development are considered, a strong justification for public financial support of an HSR project could be made.

No new transportation system of this magnitude can be developed entirely risk-free. Some uncertainties must be associated with any piece of new construction on new right-of-way—which is extensive in Alternatives D and E. No system was considered in this study, however, that had not proven its technological feasibility. Alternative C uses essentially time-tested technology, except for the carbody tilt system. Alternative D also has a significant service record, but it has a greater implementation risk than C because it requires more new construction and greater care in building and maintaining track to close tolerances. Maglev has been proved as a

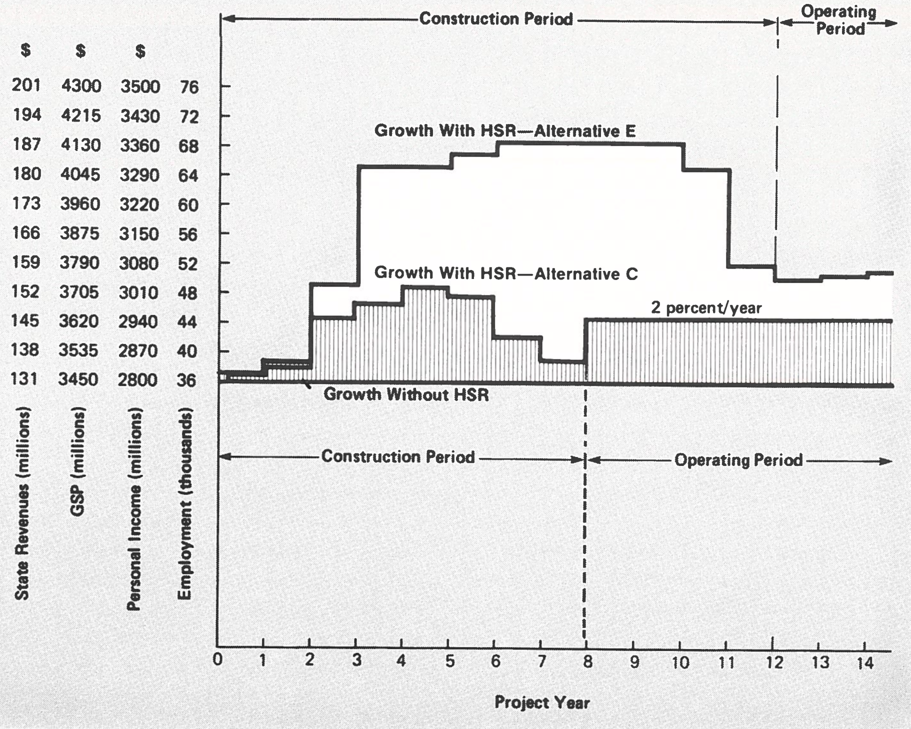
## Pennsylvania's Estimated Share of Construction Expenditures



## Distribution of Construction Period Impacts by Industry Sector—Alternative C



## Impact of HSR on Economic Growth
Base Demand



## Statewide Construction Period Impacts

| Economic Indicator | Alternative C | C-Electric | D | E |
|---|---|---|---|---|
| Capital Cost, millions | $ 1,845 | $ 2,204 | $ 7,169 | $10,024 |
| Number of Construction Years | 8 | 8 | 10 | 12 |
| Peak Year Expenditures | 23% | 23% | 17% | 11% |
| Pennsylvania Capture Rate | 71% | 70% | 72% | 66% |
| Employment Impact | | | | |
| Direct, person-years | 18,000 | 22,000 | 75,000 | 97,000 |
| Total, person-years | 58,000 | 67,000 | 232,000 | 292,000 |
| Percent Increase in Pennsylvania Growth Rate | 20% | 24% | 64% | 68% |
| Personal Income | | | | |
| Direct, millions | $ 400 | $ 500 | $ 1,500 | $ 2,000 |
| Total, millions | $ 1,000 | $ 1,200 | $ 4,100 | $ 5,200 |
| Percent Increase in Pennsylvania Growth Rate | 4% | 5% | 14% | 15% |
| Gross State Product, millions | $ 1,200 | $ 1,400 | $ 4,900 | $ 6,100 |
| Percent Increase in Pennsylvania Growth Rate | 4% | 5% | 14% | 15% |
| State Tax Revenues, millions | $ 95 | $ 110 | $ 385 | $ 490 |
| Percent Increase in Pennsylvania Growth Rate | 9% | 10% | 30% | 31% |

## Statewide Operating Period Impacts
Base Demand, Year 2000

| Economic Indicator | Alternative C | C-Electric | D | E |
|---|---|---|---|---|
| Annual O&M Cost, millions | $ 108 | $ 105 | $ 124 | $ 166 |
| Annual Ridership, millions | 4.2 | 4.2 | 5.1 | 5.9 |
| Employment Impact | | | | |
| Direct, permanent jobs | 4,500 | 4,400 | 5,300 | 6,800 |
| Total, permanent jobs | 8,300 | 8,100 | 9,600 | 12,500 |
| Percent Increase in Pennsylvania Growth Rate | 23% | 23% | 27 | 35% |
| Personal Income | | | | |
| Direct, millions | $ 85 | $ 85 | $ 100 | $ 125 |
| Total, millions | $ 140 | $ 140 | $ 160 | $ 205 |
| Percent Increase in Pennsylvania Growth Rate | 5% | 5% | 5% | 7% |
| Gross State Product, millions | $ 165 | $ 160 | $ 190 | $ 245 |
| Percent Increase in Pennsylvania Growth Rate | 5% | 5% | 5% | 7% |
| State Tax Revenues, millions | $ 13 | $ 13 | $ 15 | $ 19 |
| Percent Increase in Pennsylvania Growth Rate | 10% | 10% | 11% | 15% |

functioning principle, but not in high-speed revenue service.

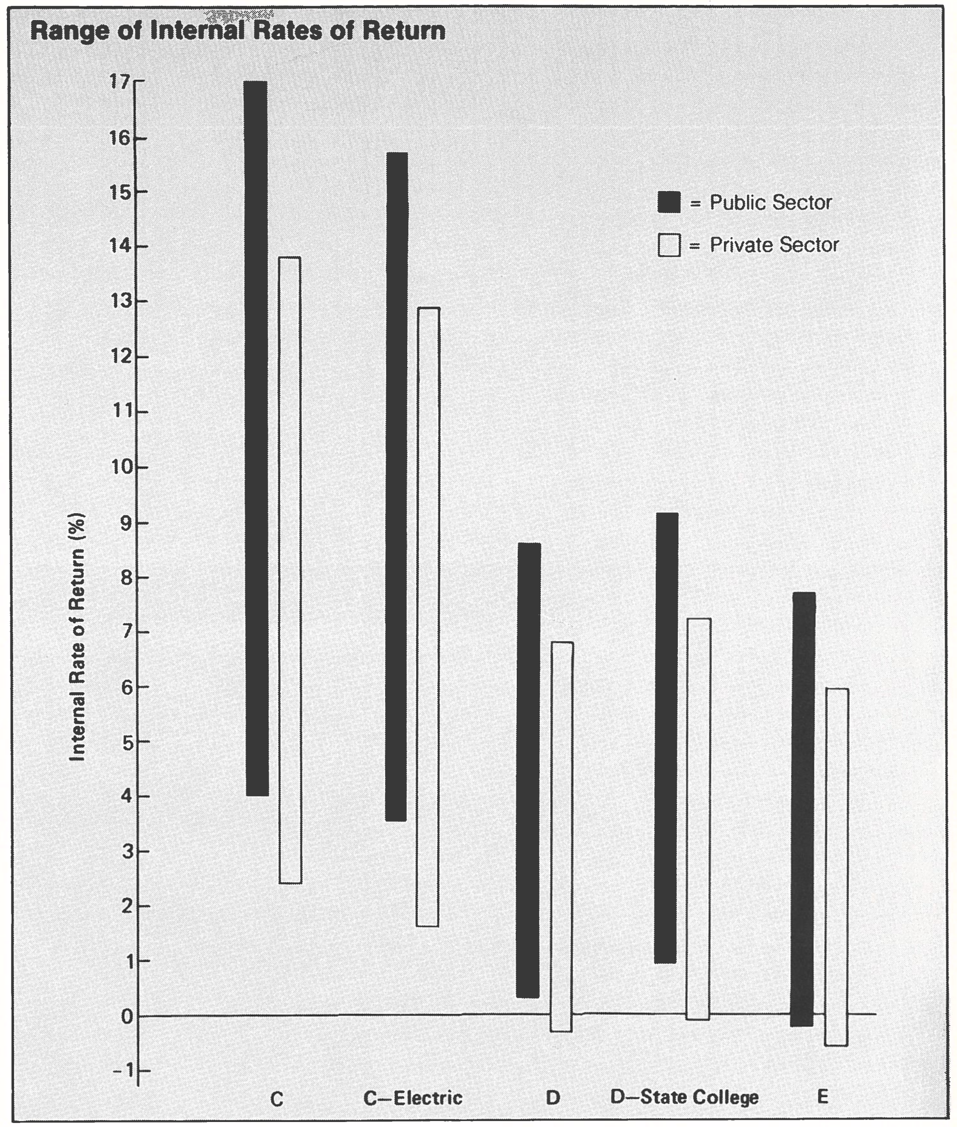
Particularly for maglev, private investors will require a higher rate of return than for a risk-free investment. At present, it appears that only Alternative C surpasses the risk-free rate of 9 percent, and then only from ridership above the base-demand conditions. It therefore seems likely that public policy, rather than investment profitability, will decide the level of support for HSR. As the study continues, public policymakers must eventually decide whether benefits themselves—time savings, greater economic impact—should be maximized, as in Alternatives D and E, or the efficiency of achieving those benefits (Alternative C).

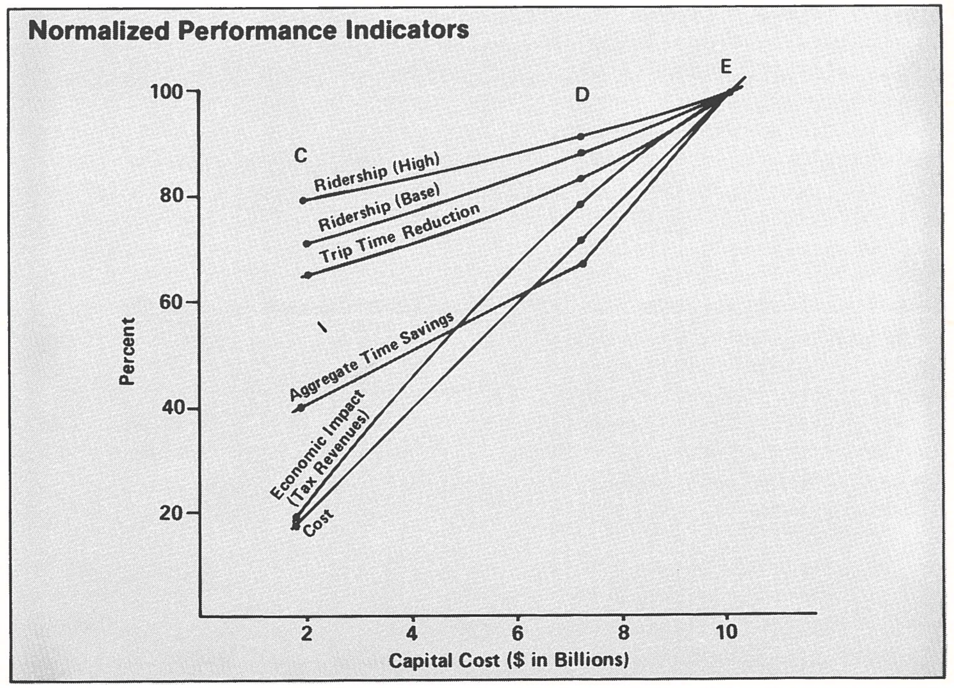
The alternatives so far considered are only first approaches. Later stages of the study will modify them, perhaps gaining important financial advantages. It is likely that vendors of equipment would offer support through loan guarantees as a way of penetrating a new market and gaining a showcase for their equipment. Adding State College to the route could raise ridership; innovative financing can also be explored, including such approaches as Florida's plan for financing transportation by allowing private investors to share in the profits of land development spurred by the new travel corridor.

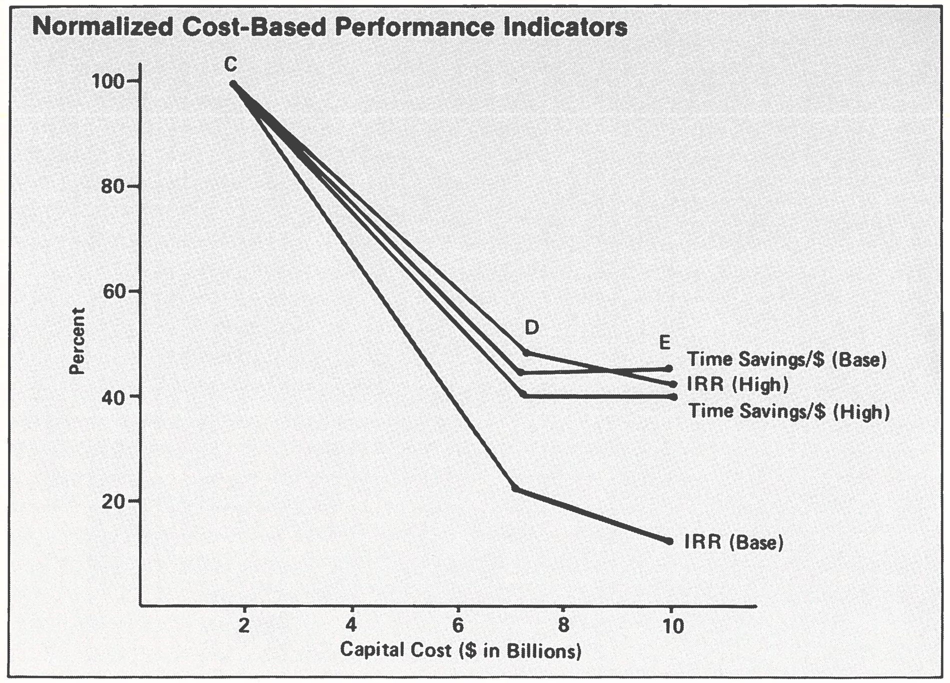
## ENVIRONMENTAL IMPACT

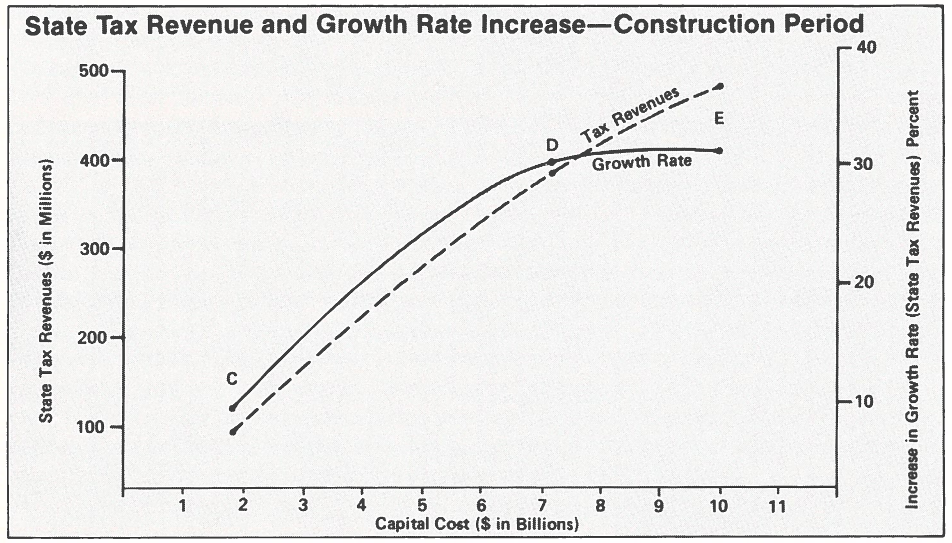
HSR will be a good neighbor. Rail in general requires only a thin strip of land to provide efficient transportation on a large scale. In virtually all categories—land required, energy consumption, noise, vibration, air pollution, and aesthetic intrusion—railroads are recognized as potentially less damaging to the environment than freeways or airports.

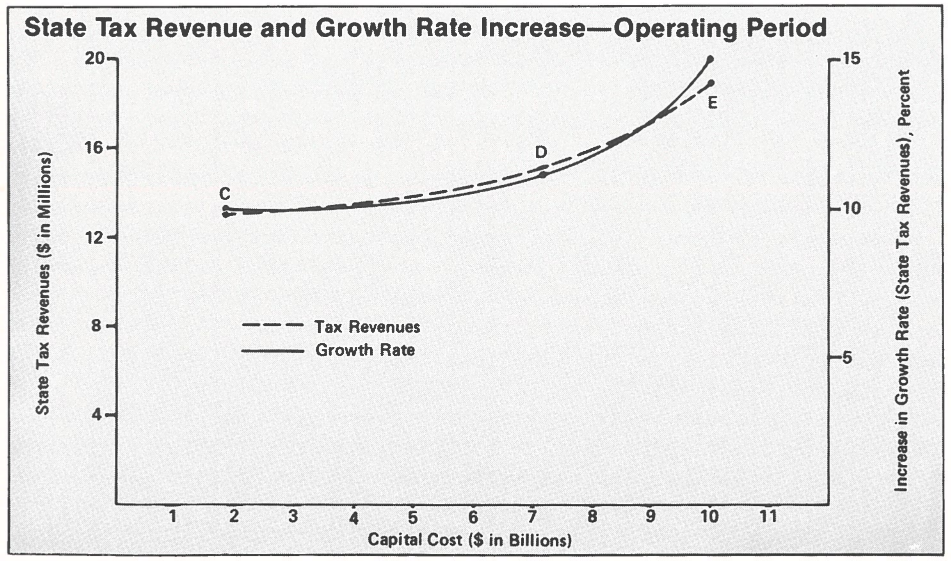
**Land Use.** For the Pennsylvania HSR line, major wetlands and state parks seem, in this preliminary overview, little affected by the planned route, except that Alternative E crosses one corner of Marsh Creek State Park in Chester County. Much of any new right-of-way will necessarily cross tracts of farm and forest that will need sensitive treatment, perhaps including elevated sections to allow agriculture on prime lands to continue uninterrupted. Historical sites near or within the rail system itself—such as Rockville Bridge, Horseshoe Curve, and certain stations, will require particular care.


**Range of Internal Rates of Return**


**Normalized Performance Indicators**


**Normalized Cost-Based Performance Indicators**

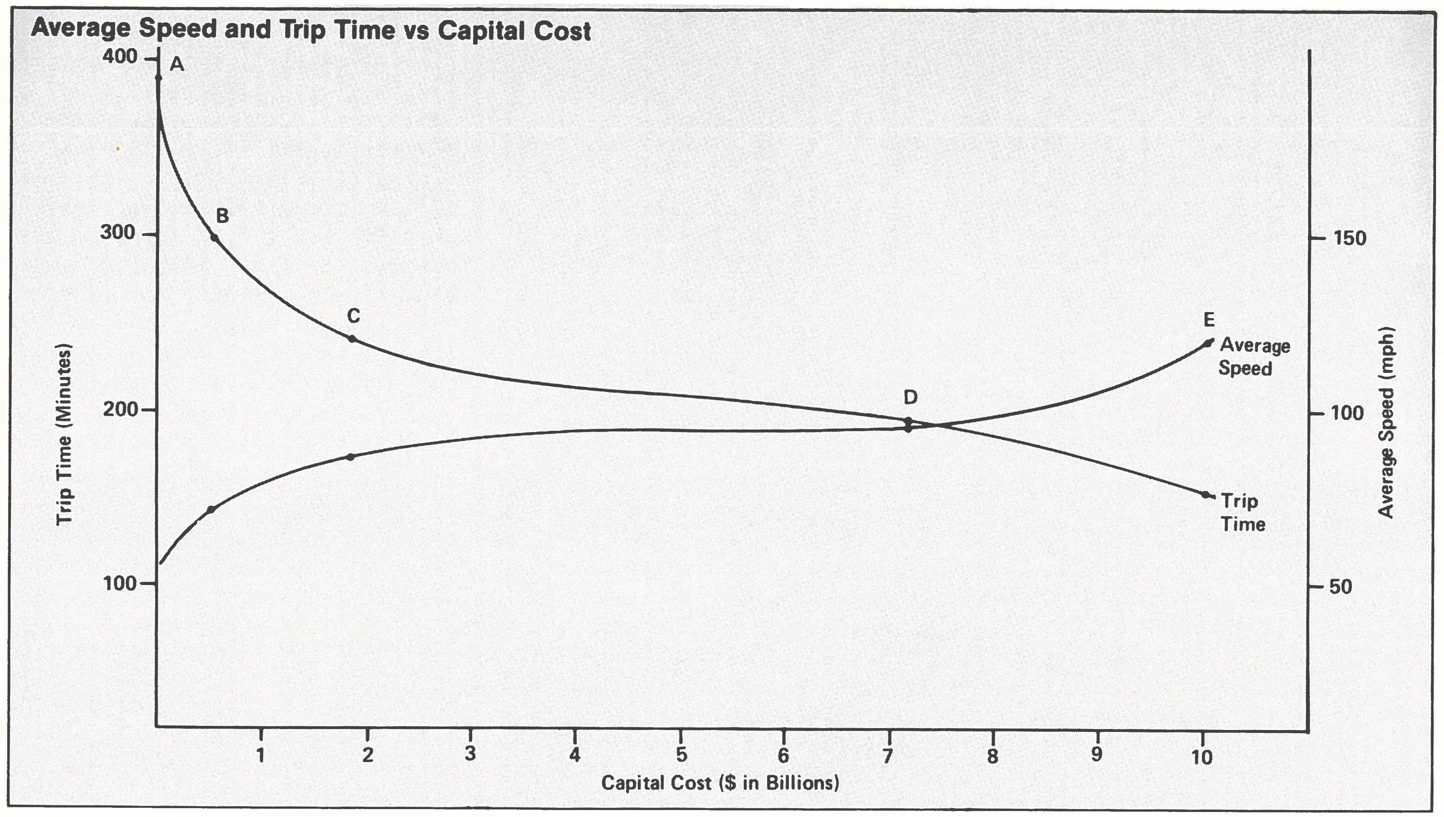

**State Tax Revenue and Growth Rate Increase—Construction Period**


**State Tax Revenue and Growth Rate Increase—Operating Period**

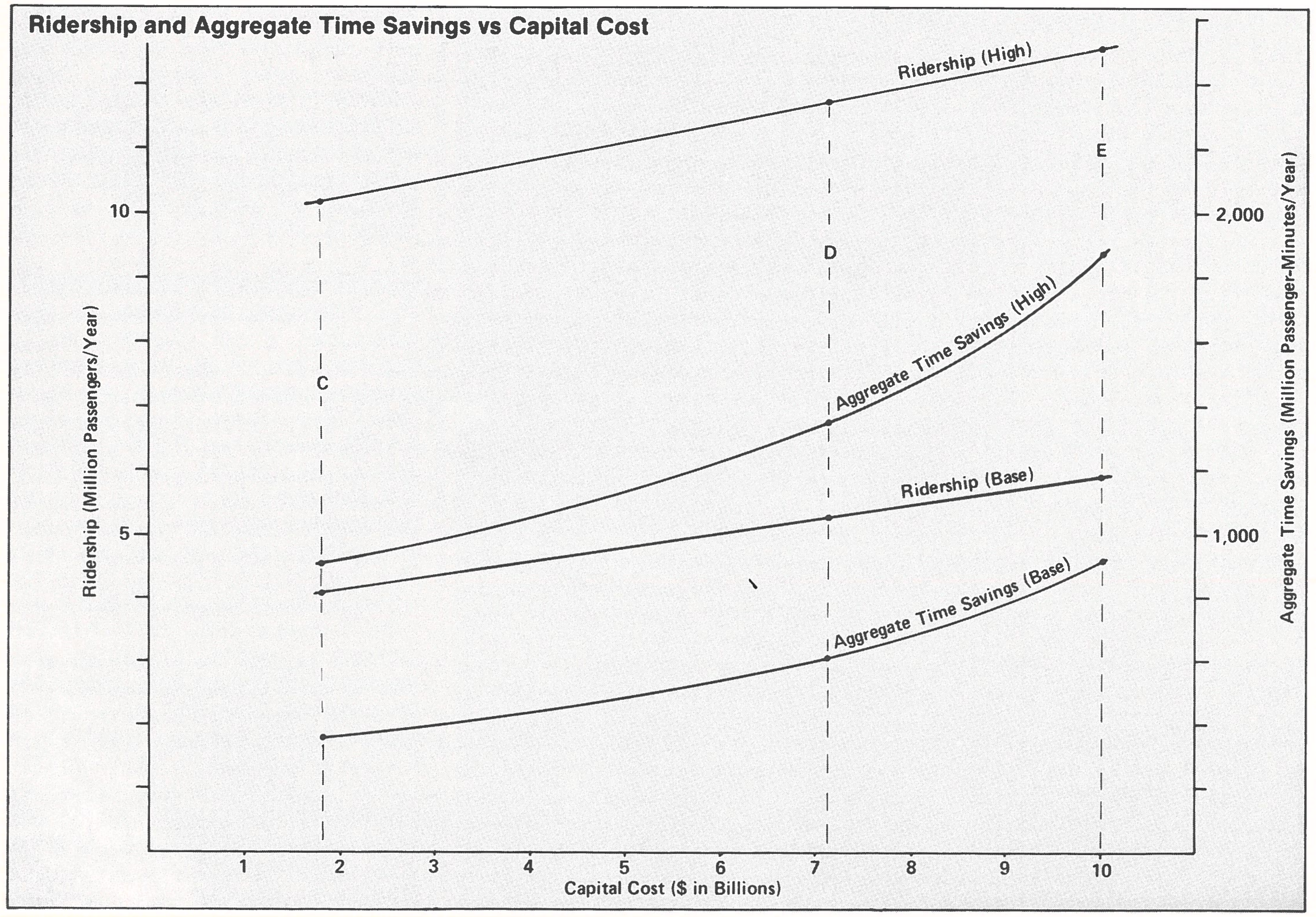
**Noise.** Steel-wheel HSR trains are free from much of the noise of ordinary rail because of smoother track and electric propulsion. Maglev creates no wheel/track noise or vibration once it attains its lift-off speed. At high speed, all designs produce aerodynamic sounds that sometimes require noise control, as has been routinely provided in Japan wherever the Shinkansen traverses residential areas.

**Health and Safety.** The maglev alternative will need special study to determine whether magnetic fields pose any problems to riders or to people living nearby—if so, shielding can be provided. Both the German and Japanese test programs are investigating this issue. As for safety, well-maintained and -operated rail systems have excellent safety records (a tenth the fatality rate of automobiles), and Japan's Shinkansen shows that high speed rail can be astoundingly safe—20 years without a fatality or serious injury to passengers.

**Environmental Program.** While the environmental impact of any HSR alternative is not expected to be severe, Alternative C, which requires building only 50 miles of new route, would likely cause less environmental disruption than D (154 miles of new route) or E (238 miles). Any project stretching from one end of the state to the other will have substantial effects and will require early incorporation of mitigation measures into the project design. Similar problems at several sites can be handled collectively without expensive site-by-site solutions. In this process, all appropriate agencies and groups would be consulted. Developing a single programmatic environmental impact statement, supplemented by site studies as required, can simplify the gaining of environmental approvals, as compared to attempting numerous studies of individual



**Average Speed and Trip Time vs Capital Cost**



**Ridership and Aggregate Time Savings vs Capital Cost**

aspects of the system. Financing the project without federal support would mean that for the most part, only state agencies would have to approve the project, which could save approval time.

## JAPAN AND FRANCE— TWO SUCCESS STORIES

Japan and France both run HSR lines at a profit. Both have extended their systems to new lines without any guarantee of achieving the financial successes of the first—France in pursuit of a public policy that insists on a vigorous passenger rail network, Japan as part of a decentralization policy to check the steady gravitation of population to a few main cities. Japan initiated its first line in the densely populated Tokyo-Osaka corridor (2,600 persons per square mile), where rail demand already exceeded the capacity of the existing system, but then extended it to much less densely populated corridors. France succeeded without such a dense population in the Paris-Lyon corridor (500 persons per square mile), and is now extending service to even less dense corridors.

The HSR concept has succeeded: the initial line of the Japanese system has operated profitably and fatality-free for more than 20 years. Pennsylvania can learn from these systems that success is possible, but must develop its own specific formula to achieve this goal.

## ACTION

The fundamental questions raised at this stage of the study and for which guidance of the Commission is required to undertake the next phase are:

- Which technology should be given further study for potential application in Pennsylvania—the various steel-wheel high speed rail technologies, or magnetic levitation?
- If steel-wheel technology is selected for further study, should the focus be on essentially existing rail rights-of-way (Alternative C and C—Electric) or on a largely new right-of-way such as Alternative D?

Whatever decisions are made will affect the Commonwealth for many generations to come, as have previous choices such as the decision to build the Pennsylvania Turnpike—a real success story.

### Alternative Evaluation Summary

| | C | D | E |
|---|---|---|---|
| Name of Alternative | Improved existing | HSR | Maglev |
| Equipment type | Tilt body | Electric HSR | Maglev |
| Route Length (miles) | 340.1 | 314.3 | 313 |
| Miles of New Route | 50 | 154 | 238 |
| Percent at grade | 90 | 73 | 67 |
| Percent elevated | 9 | 23 | 30 |
| Percent tunnel | 1 | 4 | 3 |
| Trip time (hours:min) | 3:58 | 3:16 | 2:36 |
| Ridership (millions/year) | | | |
| Base Demand | 4.18 | 5.15 | 5.87 |
| High Demand | 10.26 | 11.68 | 12.66 |
| Capital Cost ($ in billions) | | | |
| Base Demand | 1.84 | 7.17 | 10.0 |
| High Demand | 1.88 | 7.21 | 10.1 |
| Internal Rate of Return (%) (Public Sector) | | | |
| Base Demand | 4.7 | 1.0 | 0.5 |
| High Demand | 14.7 | 7.1 | 6.2 |
| Employment Impact | | | |
| Construction Period (person-years) | 18,000 | 75,000 | 97,000 |
| Operating Period Jobs | 8,300 | 9,600 | 12,500 |
| Increase in Pa. Growth Rate (%) | 23 | 27 | 35 |
| State Tax Revenues ($ in millions) | | | |
| Construction Period, Total | 95 | 385 | 490 |
| Operating Period, Annual | 13 | 15 | 19 |
| Environmental Impact | Probably not significant | Significant but can be mitigated | Significant but can be mitigated |
| Implementation Risk | Lowest | Medium | Highest |
| Compatible (with potential through service) | Yes | Yes | No |

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